CLAIMS

What is Claimed is:

1   1.   A method of reducing the quantization error in a plurality of beacon beams
2   wherein each beacon beam is digitally formed using a plurality of channels, comprising
3   the steps of:

4   (a)   computing quantized channel weights $\widetilde{W}_c$ from channel weights W_c for at
5   least some of the channels;

6   (b)   estimating the quantization error ΔB_a for each of the beacon beams from a
7   difference between the channel weights W_c and the computed quantized channel weights
8   $\widetilde{W}_c$; and

9   (c)   adding the estimated quantization error ΔB_a to the beacon beams.

1   2.   The method of claim 1, wherein the beacon beam comprises a
2   communication beam.

1   3.   The method of claim 1, wherein steps (a)-(c) are performed in a terrestrial
2   processor.

1   4.   The method of claim 1, wherein steps (a)-(c) are performed in a satellite
2   processor.

1   5.   The method of claim 1, further comprising the step of:
2   computing an azimuth bias angle az_{bias} and an elevation bias angle el_{bias} from the plurality
3   of quantized beacon beams.

1   6.   The method of claim 5, wherein the azimuth bias angle and elevation bias

2   angle are computed according to $az_{bias} \approx K_{az} \dfrac{2(\widetilde{E} \quad \Delta E) - 2(\widetilde{W} \quad \Delta W)}{(\widetilde{E})^2 + (\widetilde{W})^2}$,

3   $el_{bias} \approx K_{el} \dfrac{2(\widetilde{N} \quad \Delta N) - 2(\widetilde{S} \quad \Delta S)}{(\widetilde{N})^2 + (\widetilde{S})^2}$.

4   wherein, $\widetilde{N}$, $\widetilde{S}$, $\widetilde{E}$, $\widetilde{W}$ are predicted beam magnitudes for a North, South, East,

5   and West beacon beams, respectively, and ΔN, ΔS, ΔE, ΔW are estimated quantization

6   errors ΔB_a for the North, South, East, and West beacon beams, respectively.

1   7.   The method of claim 5, wherein the azimuth and elevation bias angles

2   az_{bias} and el_{bias} are used to correct beacon measured angles for compensating the

3   estimated quantization errors ΔB_a.

1   8.   The method of claim 1, wherein the step of adding the estimated

2   quantization error ΔB_a to each of the beacon beams comprises the steps of:

3   estimating a channel response X_a for at least some of the channels; and

4   computing the quantization error ΔB_a from the channel response.

1   9.   The method of claim 8, wherein the quantization error ΔB_a is computed

2   from the channel response according to $\Delta B_a \approx \left(W_c - \widetilde{W}_c\right)^T X_a$.

1   10.   The method of claim 8, wherein the channel response X_a is estimated

2   according to $X_a = X_0(az, el)\big|_{t_c} \, k_c\big|_{t_c}$, wherein $X_0(az, el)\big|_{t_c}$ is a nominal response of each

3   channel at a calibration time t_c and $k_c\big|_{t_c}$ is a thermal gain factor k_c evaluated at a

4   calibration time t_c.

1   11.   The method of claim 10, further comprising the step of computing the

2   thermal gain factor k_c.

1   12.   The method of claim 11, wherein the step of computing the thermal gain

2   factor k_c comprises the steps of:

3   computing $k_c = Diag(X_0(az_c, el_c))^{-1} X_c(az_c, el_c, k_c)$, wherein $(X_0(az_c, el_c))$ is the

4   nominal value of the channel to a calibration probe placed at a location (az_c, el_c) and

5    $X_c(az_c, el_c, k_c)$ is the response of each channel to a calibration probe placed at the

6   location (az_c, el_c).

1   13.   The method of claim 1, further comprising the step of computing the

2   channel weights W_c according to:

3    $W_c = Diag(X_c(az, el, k_c))^{-1} Diag(X_0(az, el)) W = Diag(K_c)^{-1} W$, wherein W represents

4   nominal channel weights.

1   14.   An apparatus for reducing the quantization error in a plurality of beacon

2   beams wherein each beacon beam is digitally formed using a plurality of channels,

3   comprising:

4   means for computing quantized channel weights $\widetilde{W}_c$ from channel weights W_c for

5   at least some of the channels;

6   means for estimating the quantization error ΔB_a for each of the beacon beams

7   from a difference between the channel weights W_c and the computed quantized channel

8   weights $\widetilde{W}_c$; and

9   means for adding the estimated quantization error ΔB_a to the beacon beams.

1   15.   The apparatus of claim 14, wherein the beacon beam comprises a

2   communication beam.

1   16.   The apparatus of claim 14, wherein the means for computing quantized

2   channel weights $\widetilde{W}_c$ from channel weights W_c for at least some of the channels, means for

3   estimating the quantization error ΔB_a for each of the beacon beams from a difference

4   between the channel weights W_c and the computed quantized channel weights $\widetilde{W}_c$; and

5   means for adding the estimated quantization error ΔB_a to the beacon beams comprises a

6   terrestrial processor.

1   17.   The apparatus of claim 14, wherein the means for computing quantized

2   channel weights $\widetilde{W}_c$ from channel weights W_c for at least some of the channels, means for

3   estimating the quantization error ΔB_a for each of the beacon beams from a difference

4   between the channel weights W_c and the computed quantized channel weights $\widetilde{W}_c$; and

5   means for adding the estimated quantization error ΔB_a to the beacon beams comprises a

6   satellite processor.

1   18.   The apparatus of claim 14, further comprising:

2   means for computing an azimuth bias angle az_{bias} and an elevation bias angle el_{bias}

3   from the plurality of quantized beacon beams.

1   19.   The apparatus of claim 18, wherein the azimuth bias angle and elevation

2   bias angle are computed according to $az_{bias} \approx K_{az} \dfrac{2(\tilde{E} \quad \Delta E) - 2(\tilde{W} \quad \Delta W)}{(\tilde{E})^2 + (\tilde{W})^2}$,

3    $el_{bias} \approx K_{el} \dfrac{2(\tilde{N} \quad \Delta N) - 2(\tilde{S} \quad \Delta S)}{(\tilde{N})^2 + (\tilde{S})^2}$

4   wherein, $\tilde{N}$, $\tilde{S}$, $\tilde{E}$, $\tilde{W}$ are predicted beam magnitudes for a North, South, East,

5   and West beacon beams, respectively, and ΔN, ΔS, ΔE, ΔW are estimated quantization

6   errors ΔB_a for the North, South, East, and West beacon beams, respectively.

1   20.   The apparatus of claim 18, wherein the azimuth and elevation bias angles

2   az_{bias} and el_{bias} are used to correct beacon measured angles for compensating the

3   estimated quantization errors ΔB_a.

1   21.   The apparatus of claim 14, wherein the means for adding the estimated

2   quantization error ΔB_a to each of the beacon beams comprises:

3   means for estimating a channel response X_a for at least some of the channels; and

4   means for computing the quantization error ΔB_a from the channel response.

1   22.   The apparatus of claim 21, wherein the quantization error ΔB_a is

2   computed from the channel response according to $\Delta B_a \approx (W_c - \tilde{W}_c)^T X_a$.

1   23.   The apparatus of claim 21, wherein the channel response X_a is estimated

2   according to $X_a = X_0(az, el)\big|_{t_c} k_c\big|_{t_c}$, wherein $X_0(az, el)\big|_{t_c}$ is a nominal response of each

3   channel at a calibration time t_c and $k_c\big|_{t_c}$ is a thermal gain factor k_c evaluated at a

4   calibration time t_c.

1   24.   The apparatus of claim 23, further comprising means for computing the

2   thermal gain factor k_c.

1   25.   The apparatus of claim 24, wherein the means for computing the thermal

2   gain factor k_c comprises:

3   means for computing $k_c = Diag(X_0(az_c, el_c))^{-1} X_c(az_c, el_c, k_c)$, wherein

4    $(X_0(az_c, el_c))$ is the nominal value of the channel to a calibration probe placed at a

5   location (az_c, el_c) and $X_c(az_c, el_c, k_c)$ is the response of each channel to a calibration

6   probe placed at the location (az_c, el_c).

1   26.   The apparatus of claim 25, further comprising means for computing the

2   channel weights W_c according to:

3    $W_c = Diag(X_c(az, el, k_c))^{-1} Diag(X_0(az, el)) W = Diag(K_c)^{-1} W$, wherein W represents

4   nominal channel weights.

1   27.   A method for reducing the asymmetry error in a beacon, wherein the
2   beacon comprises of multiple beams, and each beam is formed from a multiplicity of feed
3   channels, comprising the step of:
4   (a)   computing asymmetry angles; and
5   (b)   using the asymmetry angles to correct the beacon sensor measurements.

1   28.   The method of claim 27, wherein the step of using the asymmetry angles
2   to correct the beacon sensor measurements includes the step of using the asymmetry
3   angles as beacon bias angles.

1   29.   The method of claim 27, wherein the step of using the asymmetry angles
2   to correct the beacon sensor measurements includes the step of using the asymmetry
3   angles as time-varying beacon bias angles.

1   30.   The method of claim 27, wherein steps (a)-(b) are performed in a
2   terrestrially-based processor.

1   31.   The method of claim 27, wherein steps (a)-(b) are performed by a satellite
2   processor.

1   32.   The method of claim 29, wherein the step of computing the asymmetry
2   angles comprises the step of:
3   computing a difference between known azimuth/elevation angles, (az el), and their
4   corresponding predicted beam-formed azimuth/elevation angles, $(az_c\ el_c):(az-az_c\ el-el_c)$.

1   33.   The method of claim 32, wherein the corresponding beam-formed

2   azimuth/elevation angles are computed according to $az_c = K_{az} \dfrac{E^2 - W^2}{E^2 + W^2}$, and

3   $el_c = K_{el} \dfrac{N^2 - S^2}{N^2 + S^2}$ where K_{az} and K_{el} are optimal beacon slopes, and E, W, N, and S are

4   East, West, North, and South beam magnitudes of the beacon beams.

1   34.   The method of claim 33, wherein the E, W, N, and S beam magnitudes of

2   the beacon are computed according to:

3      $E(az, el) = W_E{}^T X$;

4      $W(az, el) = W_W{}^T X$;

5      $N(az, el) = W_N{}^T X$;

6      $S(az, el) = W_S{}^T X$; and

7   wherein the W_E, W_W, W_N, and W_S are the channel weights of East, West, North,

8   and South beacon beams, and X is a response of a plurality of feed chains at look angle

9   (az el).

1   35.   An apparatus for reducing the asymmetry error in a beacon, wherein the

2   beacon comprises of multiple beams, and each beam is formed from a multiplicity of feed

3   channels, comprising the step of:

4   means for computing asymmetry angles; and

5   means for using the asymmetry angles to correct the beacon sensor measurements.

1   36.   The apparatus of claim 35, wherein the means for using the asymmetry

2   angles to correct the beacon sensor measurements includes means for using the

3   asymmetry angles as beacon bias angles.

1   37.   The apparatus of claim 35, wherein the means for using the asymmetry

2   angles to correct the beacon sensor measurements includes means for using the

3   asymmetry angles as time-varying beacon bias angles.

1   38.   The apparatus of claim 35, wherein the means for computing asymmetry

2   angles and the means for using the asymmetry angles to correct the beacon sensor

3   measurements comprise a terrestrially-based processor.

1   39.   The apparatus of claim 35, wherein the means for computing asymmetry

2   angles and the means for using the asymmetry angles to correct the beacon sensor

3   measurements comprise a satellite-based processor.

1   40.   The apparatus of claim 35, wherein the means for computing the

2   asymmetry angles comprises:

3   means for computing a difference between known azimuth/elevation angles, (az

4   el), and their corresponding predicted beam-formed azimuth/elevation angles, (az$_c$

5   el$_c$):(az-az$_c$ el-el$_c$).

1   41.   The apparatus of claim 40, wherein the corresponding beam-formed

2   azimuth/elevation angles are computed according to $az_c = K_{az} \dfrac{E^2 - W^2}{E^2 + W^2}$, and

3    $el_c = K_{el} \dfrac{N^2 - S^2}{N^2 + S^2}$ where K_{az} and K_{el} are optimal beacon slopes, and E, W, N, and S are

4   East, West, North, and South beam magnitudes of the beacon beams.

1　　　42.　　The apparatus of claim 41, wherein the E, W, N, and S beam magnitudes
2　of the beacon are computed according to:

3　　　　　$E(az,el) = W_E^T X$;

4　　　　　$W(az,el) = W_W^T X$;

5　　　　　$N(az,el) = W_N^T X$;

6　　　　　$S(az,el) = W_S^T X$; and

7　　　　　wherein the W_E, W_W, W_N, and W_S are the channel weights of East, West, North,
8　and South beacon beams, and X is a response of a plurality of feed chains at look angle
9　(az el).